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Comparing Virtual and Traditional Physical Activity Programs: Systematic Review

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INTRODUCTION

Review question / Objective This study will aim to analyze the effects of virtual physical activity programs (VR) compared to traditional training (TR), considering participants' physical, psychological, and cognitive aspects.

Rationale This study will analyse VR's effects compared to TR, considering participants' physical, psychological, and cognitive aspects. VR will be explored as a crucial tool for expanding access to physical activity, particularly for individuals facing barriers to traditional exercise. A systematic review will follow PRISMA guidelines, with searches across multiple electronic databases to identify relevant studies from 1995 to 2025. The research will focus on primary outcomes related to physical and cognitive performance and secondary outcomes examining participant perceptions and psychological effects. The study is expected to reveal that VR training significantly enhances flexibility, motivation, and cognitive abilities, particularly for populations with limited access to traditional exercise methods. It will also assess whether the most effective VR programs are those lasting 8–12 weeks with moderate to high activity intensity. In contrast, TR is anticipated to demonstrate greater effectiveness in developing strength, endurance, and cardiorespiratory functions. Given the variability in study methodologies, short program durations, and sample heterogeneity, the study will emphasize the need for further longitudinal research. Standardizing VR training parameters will be necessary to ensure consistent and reliable outcomes.Abstract: (1) Background: This study aimed to analyze the effects of virtual physical activity programs (VR) compared to traditional training (TR), considering participants' physical, psychological, and cognitive aspects. VR has played a crucial role in expanding access to physical activity, particularly during the COVID-19 pandemic; (2) Methods: A systematic review was conducted following PRISMA guidelines. Electronic databases (PubMed, Web of Science, Scopus, MEDLINE, ERIC, Google Scholar) were searched from 1995 to 2024 using relevant keywords. A total of 23 studies meeting the PICOS model criteria were selected. Primary outcomes included physical and cognitive performance, while secondary outcomes encompassed participant perceptions and psychological effects; (3) Results: The findings indicate that VR training significantly enhances flexibility, motivation, and cognitive abilities, particularly among populations with limited access to traditional exercise methods. The most pronounced effects were observed in programs lasting 8–12 weeks with moderate to high activity intensity. In contrast, TR demonstrated superiority in developing strength, endurance, and cardiorespiratory functions; (4) Conclusions: VR offers significant benefits as an adjunct or alternative to TR, particularly for individuals with limited resources or physical accessibility. However, variations in methodological approaches, short program durations, and sample heterogeneity highlight the need for further longitudinal research. Standardizing VR training duration and intensity is essential to ensure consistent and reliable outcomes.

Condition being studied Physical inactivity is a global health concern that significantly increases the risk of chronic diseases such as type 2 diabetes, colon cancer, and coronary heart disease. According to the World Health Organization (WHO), approximately 80% of adolescents and 25% of adults worldwide fail to meet recommended physical activity levels, contributing to nearly 9% of global mortality. The rise in sedentary lifestyles, largely driven by urbanization, limited recreational opportunities, and time constraints, has further exacerbated this issue.

Engaging in regular physical activity is essential for maintaining overall health, improving cardiovascular function, and enhancing mental well-being. Traditional exercise methods such as running, cycling, and strength training have long been recognized for their benefits in building muscle mass, reducing fat, and promoting psychological resilience. However, barriers such as lack of time, access to facilities, and environmental factors often limit participation.

To address these challenges, virtual reality (VR)-based exercise has emerged as an innovative alternative. VR technology provides an immersive digital training environment where external conditions such as weather and lighting are irrelevant, making it an accessible option for individuals with restricted mobility or limited access to traditional exercise facilities. The COVID-19 pandemic further underscored the potential of VR in expanding fitness opportunities, particularly for older adults, individuals in rural areas, and those with time constraints.

VR-based training offers several advantages over conventional exercise methods. It enables users to personalize workout programs, enhances motivation through interactive engagement, and provides real-time performance tracking. Advanced VR systems incorporate head-mounted displays (HMDs) and motion-sensing controllers, allowing users to engage in activities such as virtual cycling, interactive strength training, and gamified fitness challenges. Platforms like Oculus Rift, PlayStation VR, and HTC Vive have facilitated the development of exercise programs that improve balance, coordination, strength, and flexibility.

While VR cannot fully replace traditional physical activity, studies suggest it serves as an effective supplement, particularly for individuals with limited exercise options. Research indicates that VR training can enhance motor skills, alleviate anxiety and fatigue, and even aid in rehabilitation for conditions such as stroke recovery and post-traumatic stress disorder. Additionally, VR-based interventions have been used to promote stress reduction and cognitive function, addressing the psychological imbalances exacerbated by modern sedentary lifestyles.

Given the growing relevance of VR in the fitness industry, further research is needed to standardize training protocols and optimize program duration and intensity. Understanding the long-term effects of VR-based exercise on physical and mental health will be crucial in determining its full potential as a sustainable fitness solution.

METHODS

Search strategy A systematic and transparent approach to data collection, analysis, and selection will be implemented to ensure validity, minimize bias, and maintain the reliability of findings. To achieve these objectives, the study will adhere to the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses).

The electronic literature search will be conducted across multiple databases to ensure comprehensive coverage of relevant studies. The selected databases will include: PubMed, Web of Science, Scopus, MEDLINE, ERIC, and Google Scholar.

The search will target studies published between 1995 and 2025. A combination of keywords related to virtual reality (VR) and physical activity will be used to refine the search strategy. The primary keywords will include: Effectiveness, Virtual Training, Digital Exercise, Online Fitness, Influence. To enhance sensitivity and ensure that all relevant literature is captured, the search strategy will be adapted for each database based on its specific indexing system.

A predefined set of inclusion and exclusion criteria will be established using the PICOS (Population, Intervention, Comparators, Outcomes, and Study Design) framework to ensure objectivity and relevance in study selection.

PICOS Category.

P (Population) – Inclusion Criteria: Men and women, regardless of restrictions on lifestyle, age and health status; Exclusion

Criteria: People with serious health problems or injuries that prevent physical activity;

I (Intervention) – Inclusion Criteria: Papers in which an experimental procedure was used in which several groups participated, as well as papers where data were collected through questionnaires or interviews; Exclusion

Criteria: Incompatibility with virtual methods; Methods whose primary focus is not physical and cognitive training, it is a personal impression;

C (Comparators) – Inclusion Criteria: Studies comparing experimental and control groups (eg, VA vs. CG, IPE vs. NA, etc.) or comparing different groups within virtual training (eg, EXP1 vs. EXP2, PA vs. VA); Exclusion

Criteria: Studies between unrelated sports (eg men's basketball players vs. handball players or soccer players);

O (Outcomes) – Inclusion Criteria: Effects of virtual activity (VA-VR) on physical and cognitive abilities after implementation of the program; Information about the personal impression of the respondent; Exclusion Criteria: Incomplete results;

S (study design) – Inclusion Criteria: Longitudinal and transferal studies; Language was not a criterion for choosing a study. Duplicates; Studies that were systematic reviews; Inappropriate time frame of analysis (1995–2024);

S (Study design) – Inclusion criteria: Randomized and non-randomized controlled studies; Studies written in Serbian and English; Exclusion Criteria: Duplicates; Conference abstracts; Case reports (e.g., <5 participants per group); Review articles; Inappropriate frame of analysis in the period between 2008-2024 years; Studies written in a language which was not Serbian or English.

To ensure accuracy and reliability in study selection, a three-step evaluation process will be applied:

Initial Screening – Two authors (N.A. and S.B.) will independently review the titles and abstracts of all identified studies.

Full-text review – The same authors will cross-verify their selections to confirm the relevance of each study.

Final Selection – Any discrepancies will be resolved through discussion, with a third researcher (R.A.) making the final decision if consensus cannot be reached.

To manage references efficiently, EndNote will be used for citation management, while Mendeley (v. 2.111.0, Elsevier Ltd., Barcelona, Spain) will be employed to detect and remove duplicate entries.

The methodological quality of the included studies will be evaluated using the Physiotherapy Evidence Database (PEDro) scale, which consists of 11 criteria. Each study will be assessed using a binary rating system (+ or -) or a numerical scale (1 or 0). Based on PEDro scores, studies will be classified as: - High quality (≥6 points); - Moderate quality (4–5 points); - Low quality (<4 points). Studies with low-quality ratings will be critically examined for potential biases and methodological limitations, which will be further discussed in the Discussion section.

Participant or population The review will address a diverse range of participants, ensuring broad applicability of findings. The PICOS framework (Population, Intervention, Comparators, Outcomes, and Study Design) will guide participant selection. The target population will include: 1. General Population (Men and women of all ages will be included, allowing for the examination of virtual physical activity (VR) effects across different life stages. No restrictions will be placed on lifestyle habits, ensuring representation of individuals with varying levels of daily activity); 2. Healthy Individuals and Individuals with Minor Health Conditions (The review will focus on individuals without severe health complications that would prevent participation in physical activity. Those with minor health conditions (e.g., mild obesity, hypertension, or sedentary lifestyles) will be considered to explore the potential benefits of VR-based physical activity interventions); 3. Athletes and Physically Active Individuals (Studies involving athletes or individuals engaged in regular physical training will be included to assess VR's effectiveness in enhancing performance, endurance, coordination, and skill development); 4. Special Populations (Older Adults – Studies investigating VR training for aging populations will be included to assess its impact on balance, mobility, flexibility, and cognitive function. Individuals from Rural Areas or Those with Limited Access to Traditional Exercise – The review will explore VR's role in providing accessible physical activity options); 5. Excluded Participants (Individuals with severe health conditions (e.g., serious heart disease, post-surgical restrictions, advanced neurological disorders) will be excluded as they may require specialized rehabilitation not covered in standard VR fitness programs. Studies involving individuals unable to perform physical activity due to injury or disability that severely limits movement will not be considered).

Intervention The review will focus on VR interventions that integrate immersive technology to enhance physical activity experiences. These programs will include fully immersive VR training using head-mounted displays (HMDs) such as Oculus Rift, HTC Vive, and PlayStation VR, semi-immersive VR programs using motion-sensing cameras (e.g., Kinect, Nintendo Wii) to track body movements, and non-immersive VR training utilizing mobile applications, 2D virtual exercise programs, or online fitness platforms. The review will examine VR interventions tailored for different age groups, fitness levels, and special populations, including general fitness programs designed for healthy individuals seeking to improve cardiovascular endurance, strength, and flexibility, rehabilitation-based VR training focused on improving motor skills, coordination, and postural stability in older adults or individuals recovering from injuries, and VR-guided sports training used by athletes to enhance agility, reaction time, and cognitive processing. The review will also assess interventions that use virtual environments to improve mental well-being, motivation, and cognitive function, including gamified fitness programs that promote engagement through interactive challenges and rewards; VR-based mindfulness and relaxation exercises aimed at reducing stress, anxiety, and mental fatigue; Virtual group training sessions that simulate social interaction and team-based physical activity.

To determine the effectiveness of these VR interventions, the review will analyze studies that measure: 1) Physical performance metrics (e.g., strength, endurance, flexibility, balance); 2) Cognitive and motor skill improvements (e.g., reaction time, coordination, memory function); and 3) Psychological outcomes (e.g., motivation, stress reduction, adherence to physical activity).

Comparator The review will apply a comparative intervention approach to evaluate the effectiveness of virtual reality-based physical activity (VR) programs against traditional training (TR) methods in the target population. This comparison will allow for a clear assessment of how VR interventions influence physical, cognitive, and psychological outcomes relative to conventional exercise approaches.

1. Virtual Reality-Based Physical Activity (Experimental Group)

The VR-based interventions will serve as the experimental condition and will include:

Fully immersive VR training using head-mounted displays (HMDs) like Oculus Rift, HTC Vive, and PlayStation VR.

Semi-immersive VR programs employing motion-sensing technology (e.g., Microsoft Kinect, Nintendo Wii, or similar devices).

Non-immersive digital exercise programs delivered through mobile applications or online platforms.

These interventions will aim to improve motor skills, cardiovascular endurance, cognitive function, and psychological well-being through engaging, gamified, and interactive training sessions.

2. Traditional Training (Control Group or Comparative Condition)

The comparative intervention will consist of conventional physical activity methods that have been widely used in sports science and fitness training. This group will follow structured training programs that do not involve VR technology, including:

Aerobic exercise programs (e.g., treadmill running, cycling, and swimming).

Strength training using free weights, resistance machines, or bodyweight exercises.

Flexibility and balance training (e.g., yoga, pilates, or traditional rehabilitation exercises).

Participants will engage in these activities under standardized conditions, and their progress will be monitored using established physical performance and psychological well-being metrics.

Study designs to be included The review will include randomized and non-randomized controlled trials, longitudinal and cross-sectional studies that evaluate the effects of virtual reality-based physical activity (VR) programs compared to traditional training (TR) methods. Studies will be selected based on the PICOS model, focusing on physical, cognitive, and psychological outcomes. Systematic reviews, conference abstracts, case reports with fewer than five participants per group, and studies outside the 1995–2024 timeframe will be excluded.

Eligibility criteria The following additional inclusion or exclusion criteria, not explicitly defined within the PICOS framework, can be inferred: Additional Inclusion Criteria – Longitudinal and transferal studies are included; Studies published between 1995 and 2024 are eligible; Studies that are written in either Serbian or English are included; Papers that used experimental procedures with multiple groups; Studies involving data collection via questionnaires or interviews; Studies that compare experimental groups to control groups (e.g., VA vs. CG, IPE vs. NA) or different virtual training methods (e.g., EXP1 vs. EXP2); Studies that report the effects of virtual activity (VR) on physical and cognitive abilities. Additional Exclusion Criteria – People with serious health problems or injuries that prevent physical activity. Studies that do not focus on virtual methods or whose primary focus is not physical and cognitive training. Studies based solely on personal impressions. Studies comparing unrelated sports (e.g., men's basketball players vs. handball players or soccer players). Studies with incomplete results. Duplicate studies. Studies classified as systematic reviews or those using inappropriate time frames (e.g., not within 1995–2024).

Conference abstracts. Case reports with fewer than five participants per group. Review articles. Studies written in languages other than Serbian or English.

Information sources In the systematic review, the following information sources will be utilized to ensure comprehensive data collection and enhance the reliability and validity of the findings:

Electronic Databases – The primary source for identifying relevant studies will be the use of multiple electronic databases. The review will search major databases such as PubMed, Web of Science, Scopus, MEDLINE, ERIC, and Google Scholar. These databases are expected to provide a wide range of studies related to virtual reality, physical activity, and cognitive training. The search will be refined using a combination of key terms such as "Effectiveness," "Virtual Training," "Digital Exercise," "Online Fitness," and "Influence," focusing on studies published between 1995 and 2024. Each database will be searched individually with tailored search strategies to enhance sensitivity and retrieve the most relevant articles.

Trial Registers – The review will explore trial registers such as ClinicalTrials.gov and the WHO International Clinical Trials Registry Platform (ICTRP) to identify ongoing or completed trials that may not yet be published in peer-reviewed journals. This is important to ensure that unpublished or underrepresented studies, especially those with relevant data on virtual activity and physical or cognitive training, are included in the review. These sources will help in collecting information about the methodology and outcomes of trials that may otherwise be overlooked.

Contacting Authors – If necessary, the authors of selected studies will be contacted directly to request further details or clarification on specific aspects of the research. This might include data on methods, results, or specific outcome measures not clearly reported in the study itself. This approach will be particularly helpful for retrieving incomplete or supplementary data not available in the published article.

Grey Literature – In addition to peer-reviewed journals, the review will include grey literature sources to capture studies that are not typically published in mainstream academic outlets. Grey literature may include conference proceedings, technical reports, dissertations, and unpublished manuscripts. These sources will be accessed through repositories like OpenGrey, Google Scholar, and institutional repositories of universities and research institutions. This will help minimize publication bias and ensure a more complete overview of the evidence on virtual reality-based physical and cognitive interventions.

Reference Lists – The reference lists of selected studies will also be scanned to identify additional relevant articles that may not have been captured through the initial database search. This method, often referred to as snowball sampling, will be used to ensure that key studies that have influenced the field are not overlooked.

Main outcome(s) The outcomes of the systematic review will focus on evaluating the effectiveness of VR-based interventions in improving physical and cognitive abilities. The review will specifically assess the impact of virtual activities on participants' motor skills, physical fitness, and cognitive function after the implementation of VR-based programs.

The primary outcome measures will include physical outcomes (these will encompass improvements in motor control, strength, balance, coordination, and overall physical activity levels. These measures will be obtained from studies that assess the physical performance of participants using VR-based training programs), cognitive outcomes (the review will examine changes in cognitive function, including memory, attention, processing speed, and executive function, as assessed through validated cognitive tests used in the included studies). The systematic review will include studies of high and moderate methodological quality, with a majority of studies meeting high-quality criteria according to the Physiotherapy Evidence Database (PEDro) scale.

Data management The mechanism that will be used to manage records and data will follow a systematic and structured approach. Here's how the process will be managed:

1. Data Collection and Sources - Relevant studies will be gathered from databases such as PubMed,

Scopus, Web of Science, or other scientific repositories; Inclusion and exclusion criteria will be defined to ensure the selection of studies based on relevance, quality, and methodology; Key data points, including participant demographics, VR intervention details, outcome measures, and study findings, will be extracted from each selected study.
2. Data Storage and Organization - A centralized database or spreadsheet (e.g., Excel, SPSS, or NVivo) will be used to systematically organize the extracted data; Studies will be categorized based on variables such as study design (RCT, cohort, etc.), sample size, intervention duration, and measured outcomes; Each study will be assigned a unique identifier (e.g., DOI, author-year) to facilitate easy tracking and referencing.
3. Data Processing and Standardization - Data from different studies will be standardized for consistency; Missing or incomplete data will be addressed through imputation methods or sensitivity analyses; A quality check process will be implemented to detect and remove duplicate or inconsistent entries.
4. Analysis and Interpretation - Statistical or qualitative synthesis methods (e.g., meta-analysis or thematic analysis) will be applied to identify trends and patterns; Software such as RevMan, R, or SPSS will be used to conduct the quantitative synthesis; Correlations and potential effects of VR training on physical, psychological, and cognitive outcomes will be analyzed systematically.
5. Record Management and Documentation - A log of all included and excluded studies, along with justifications for exclusion, will be maintained; Version control mechanisms will be implemented to track changes and updates in data handling; Ethical considerations, including the anonymization of participant data (if applicable), will be strictly followed.
6. Reporting and Accessibility - Findings will be documented in tables, figures, and summary statistics for clarity and accessibility; A transparent reporting framework (e.g., PRISMA guidelines) will be followed to ensure methodological rigor;
Data may be shared in supplementary materials or open-access repositories to enhance reproducibility and facilitate further research.

Quality assessment / Risk of bias analysis The quality assessment of primary studies in the analysis of the effects of VR training on physical, psychological, and cognitive outcomes will follow a structured and standardized approach. This process will ensure that only high-quality, reliable, and valid studies contribute to the overall synthesis:
1. Selection of a Quality Assessment Tool
A standardized assessment tool, such as the Cochrane Risk of Bias (RoB) tool for randomized controlled trials (RCTs) or the Newcastle-Ottawa Scale (NOS) for observational studies, will be used. If the review includes qualitative studies, tools like the Critical Appraisal Skills Programme (CASP) checklist will be applied.
2. Assessment of Study Design and Methodology
Each study will be critically evaluated based on predefined criteria, including:
Randomization and Allocation Concealment - The method of participant randomization and whether allocation will be concealed from researchers and participants;
Blinding Procedures - The extent to which participants, assessors, and intervention administrators will be blinded to reduce bias;
Sample Size and Power Analysis - Whether studies will justify their sample size and conduct power calculations to determine adequate participant numbers;
Intervention Fidelity - The consistency and accuracy of VR training protocols across study participants.
3. Evaluation of Data Reporting and Outcome Measures
Studies will be assessed on their completeness of data reporting, ensuring that all primary and secondary outcomes will be clearly presented;
The reliability and validity of measurement tools used to assess physical, psychological, and cognitive outcomes will be examined;
Potential biases, such as selective reporting or missing data, will be identified through comparisons with study protocols.
4. Overall Risk of Bias Classification - Each study will be classified as having a low, moderate, or high risk of bias based on its methodology and adherence to quality criteria.

Strategy of data synthesis The data obtained from various studies on the effects of virtual reality (VR) training on physical, psychological, and cognitive outcomes will be analyzed through a systematic and structured approach:
1. Data Extraction and Preparation - Initially, key data from each selected study will be extracted and organized into a standardized format. This process will include details such as study design, sample characteristics, intervention protocols, outcome measures, and key findings. Any discrepancies in data extraction will be resolved through independent verification by multiple reviewers.
2. Selection of Synthesis Method - The choice of data synthesis method will depend on the type and quality of the included studies. If a sufficient number of studies with similar methodologies and

outcome measures are available, a meta-analysis will be conducted. Statistical techniques will be used to pool effect sizes, providing an overall estimate of VR training's impact. If the included studies are highly heterogeneous in terms of design, interventions, or outcome measures, a narrative synthesis will be performed. This method will involve systematically summarizing and comparing study results while identifying patterns and trends.

3. Statistical Analysis in Meta-Analysis - For studies included in the meta-analysis, Effect Size Calculation will be applied. Standardized mean differences (SMD) or weighted mean differences (WMD) will be computed for continuous outcomes, while odds ratios (OR) or risk ratios (RR) will be calculated for categorical outcomes.

Heterogeneity Assessment - The degree of variability among studies will be evaluated using Cochran's Q test and I^2 statistics. If heterogeneity is high ($I^2 > 50\%$), subgroup analyses or meta-regression will be performed to explore potential sources of variation.

4. Integration of Qualitative and Quantitative Findings

If both quantitative and qualitative studies are included, an integrated approach will be adopted. The qualitative synthesis will provide contextual insights that complement the statistical findings, helping to explain variations in VR training effectiveness.

Subgroup analysis A subgroup analysis will be conducted to examine potential variations in the effects of VR training on physical, psychological, and cognitive outcomes across different study characteristics. The analysis will aim to identify factors that will influence the effectiveness of VR-based interventions, allowing for tailored recommendations based on specific population groups and intervention features.

1. Participant Characteristics

The studies will be categorized based on participant demographics, which will include:

Age Group: Participants will be divided into younger adults (e.g., 18–30 years), middle-aged adults (e.g., 31–60 years), and older adults (e.g., 60+ years) to determine whether age influences the benefits of VR training.

Gender Distribution: Studies that will report separate outcomes for male and female participants will be analyzed to explore potential gender-related differences in responses to VR interventions.

Health Status: Subgroup comparisons will be performed between healthy individuals and those with specific medical conditions (e.g., obesity, hypertension, depression, or motor impairments) to assess whether VR training will be more effective in clinical populations.

2. Intervention Characteristics

The effectiveness of VR training will be examined based on different aspects of the intervention, including:

Type of VR Exposure: Studies will be categorized based on whether the intervention will involve fully immersive VR (e.g., head-mounted displays) or semi-immersive/non-immersive VR (e.g., screen-based simulations).

Training Duration and Frequency: Studies will be grouped based on short-term (<6 weeks) versus long-term (≥6 weeks) interventions, as well as different session frequencies (e.g., 2-3 sessions per week vs. daily training).

Intervention Content: Subgroups will be formed based on the primary training focus, such as motor training (e.g., fitness-based VR), cognitive training (e.g., problem-solving VR tasks), or psychological interventions (e.g., VR therapy for mental well-being).

3. Outcome-Based Subgroups

VR training will be evaluated based on different categories of measured outcomes:

Physical Outcomes: Studies focusing on body composition (e.g., BMI, body fat), cardiovascular health (e.g., heart rate, blood pressure), motor ability, and flexibility will be analyzed separately.

Psychological Outcomes: Depression, anxiety, motivation, and emotional well-being outcomes will be assessed to determine VR's impact on mental health.

Cognitive Outcomes: Studies examining executive functions, memory, and reaction time improvements will be categorized separately to explore VR's cognitive benefits.

Sensitivity analysis The sensitivity analysis will be conducted to assess the robustness of the findings and determine whether the results will be influenced by variations in methodological decisions. The initial screening of titles and abstracts will be performed to identify relevant studies, and any uncertainties regarding eligibility will be resolved through discussion among reviewers. To further assess the impact of study selection on the final results, the sensitivity analysis will be conducted by:

Re-examining inclusion criteria: The review team will test whether the exclusion of borderline studies (those that will partially meet the inclusion criteria) will significantly alter the findings.

Adjusting search strategies: Since the search strategy will be tailored for each database, additional sensitivity tests will be performed by including or excluding specific search terms to evaluate their effect on the number and nature of retrieved studies.

To ensure data integrity, the authors will contact study authors if essential data will be missing. However, in cases where the missing data will not be critical to the study's primary outcomes, they will not be included in the analysis. The sensitivity analysis will then involve:

Testing different methods of handling missing data: The review will compare results with and without imputed data (if applicable) to assess whether the absence of certain variables will significantly influence the conclusions.

Assessing the impact of incomplete studies: If multiple studies with missing critical data are excluded, a secondary analysis will be performed to determine whether their inclusion with estimated or partial data will modify the overall trends.

To further test the reliability of the findings, sensitivity analysis will be performed by excluding studies that will be identified as having a high risk of bias (e.g., studies with poor methodological quality or small sample sizes). If the results remain stable after these exclusions, confidence in the findings will be strengthened.

Language restriction Language limits will be imposed, as only studies written in Serbian or English will be included. Studies in other languages will be excluded from the analysis.

Country(ies) involved Serbia.

Other relevant information When this study is reviewed and further developed, supplementary information related to the study selection and methodological quality process will be provided to ensure a comprehensive understanding of the evaluation process and quality of the included research. The research team will continue to utilize advanced tools and techniques to enhance the accuracy and depth of the review, as outlined below.

In the next phase of the study, the authors will continue to employ software tools such as EndNote and Mendeley to manage references, ensuring that all citations are accurately recorded and duplicates are effectively detected. These software tools will streamline the process, minimizing errors and improving efficiency in handling large numbers of references. The authors will also conduct an additional round of screening, revisiting the data to ensure that the most relevant and recent studies are included, particularly those published after the initial selection period. The research team will prioritize studies that feature cutting-edge VR instrumentation or novel methodologies, which could add valuable insights to the topic being explored.

The study selection will be done following a rigorous procedure to guarantee that the most relevant studies are included. The selection process will be transparent and replicable, with detailed inclusion and exclusion criteria explicitly defined. The research team will continue to emphasize the importance of peer-reviewed articles, prioritizing those that offer robust methodologies and substantial findings. It is expected that future studies considered for inclusion will be drawn from a wide range of sources, with particular attention to interdisciplinary research, given the evolving nature of VR and related technologies.

The process for resolving disagreements and ensuring consensus among the research team will remain an essential part of the study's methodology. The authors will continue to prioritize open communication and collaboration, involving at least two independent researchers in every decision related to study inclusion or exclusion. If disagreements persist, a third researcher will be consulted, as in the current study, to guarantee that all decisions are fair and objective. Future studies may also implement additional mechanisms for resolving conflicts, such as peer review or external consultation, to ensure that the review process is impartial and rigorous.

Further, the research team will expand its collaboration efforts, potentially involving international researchers and institutions that specialize in VR technology and rehabilitation sciences. This broader collaboration will enrich the quality of the review by incorporating insights from diverse academic perspectives and increasing the generalizability of the study's findings.

A key element in the selection process will be the focus on ensuring that studies are appropriately comparable. The research team will work to address variability in sample characteristics and instrumentation, as discussed earlier. In order to evaluate the heterogeneity of included studies effectively, the authors will group studies by relevant variables such as participant demographics, VR device specifications, and the specific interventions being tested. These categories will allow for a more granular assessment of the quality and relevance of each study, leading to more precise conclusions in the final review.

The evaluation of the methodological quality of the studies will be one of the cornerstones of the review. The authors will continue to use the Physiotherapy Evidence Database (PEDro) scale as a primary tool for assessing methodological quality. This tool will be complemented by additional quality assessments, including an updated version of the Cochrane Risk of Bias Tool to reflect changes in evidence synthesis practices. The authors will aim to include new scales or metrics that emerge from the latest research in evidence-based practice, ensuring that the evaluation of methodological rigor is both up-to-date and aligned with the best practices in the field.

Keywords Effectiveness; Virtual Training; Digital Exercise; Online Fitness; Influence.

Dissemination plans The dissemination of the findings from this study will be aimed at reaching a wide audience, including researchers, healthcare professionals, fitness experts, and the general public. First, the results will be shared through peer-reviewed journals focused on physical activity, rehabilitation, and digital health technologies. These publications will ensure that the findings are available to academics and practitioners who can apply the insights to enhance physical activity programs.

Additionally, the study will be presented at international conferences and workshops, where researchers and professionals can discuss the implications of the findings and their potential applications in clinical or community settings. Webinars and online forums will also be organized to engage a broader audience, particularly those interested in virtual training or digital fitness solutions.

The study will also be disseminated through social media platforms and specialized blogs in health and fitness, ensuring it reaches a wider public, including individuals seeking alternative or supplementary fitness methods. Infographics and summary reports will be created for easy accessibility and understanding.

Finally, the research team will collaborate with industry stakeholders, including VR technology developers and fitness program providers, to explore the potential of integrating VR into mainstream exercise programs.

Contributions of each author

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